# PHASE 1 FPIX DETECTOR FOR CMS

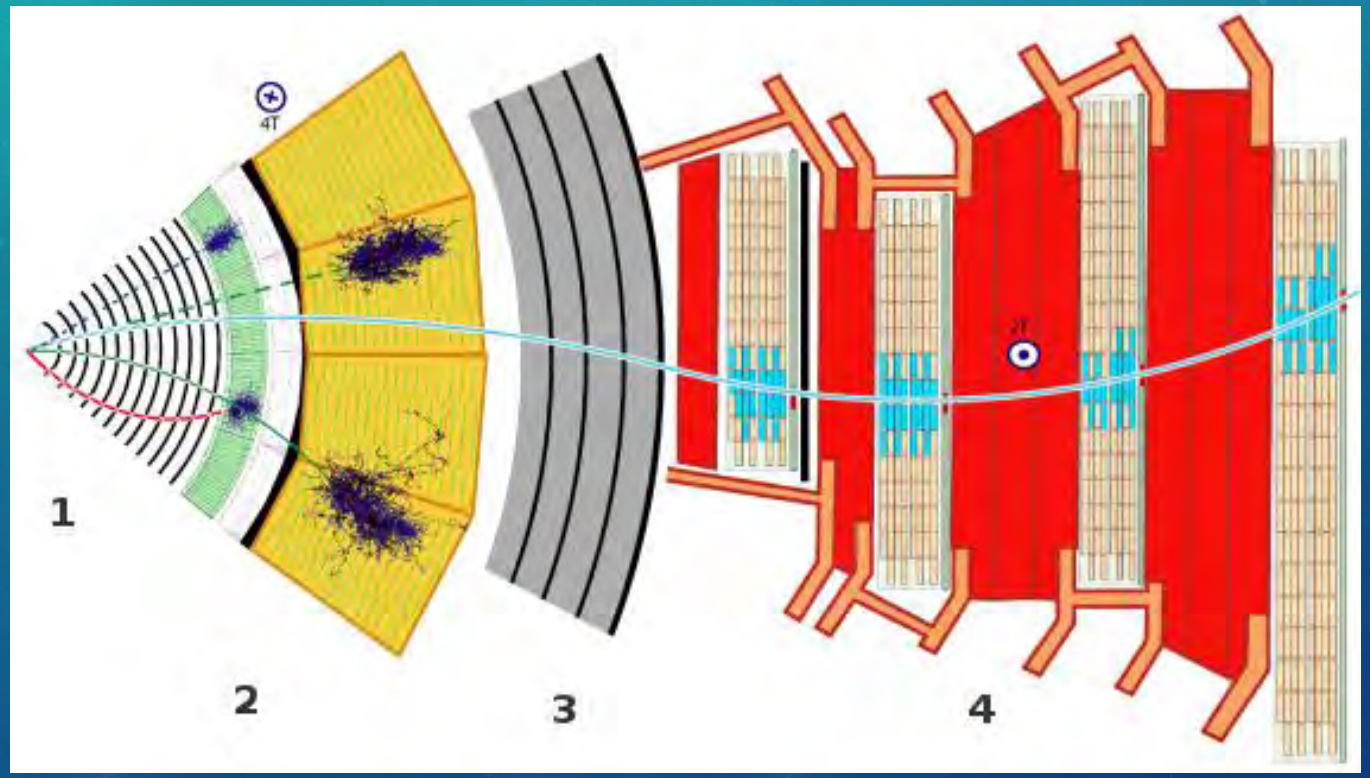
ELECTRONICS – LUKE DEVITT

MECHANICAL – JENNICE OZMENT

# BACKGROUND

- LHC increased energy from  7 TeV to 13 TeV in 2015. Current pixel detector is over 6 years old, high luminosities are expected in 2017.  This impacts efficiency and pattern recognition.
- New forward pixel detector designed and built at Fermilab
  - This detector will be right at the heart of where the collisions take place
  - The detector is made of 4 half cylinders  (HC)

# OVERVIEW OF CMS DETECTOR



# CURRENT DETECTOR VS. NEW DETECTOR

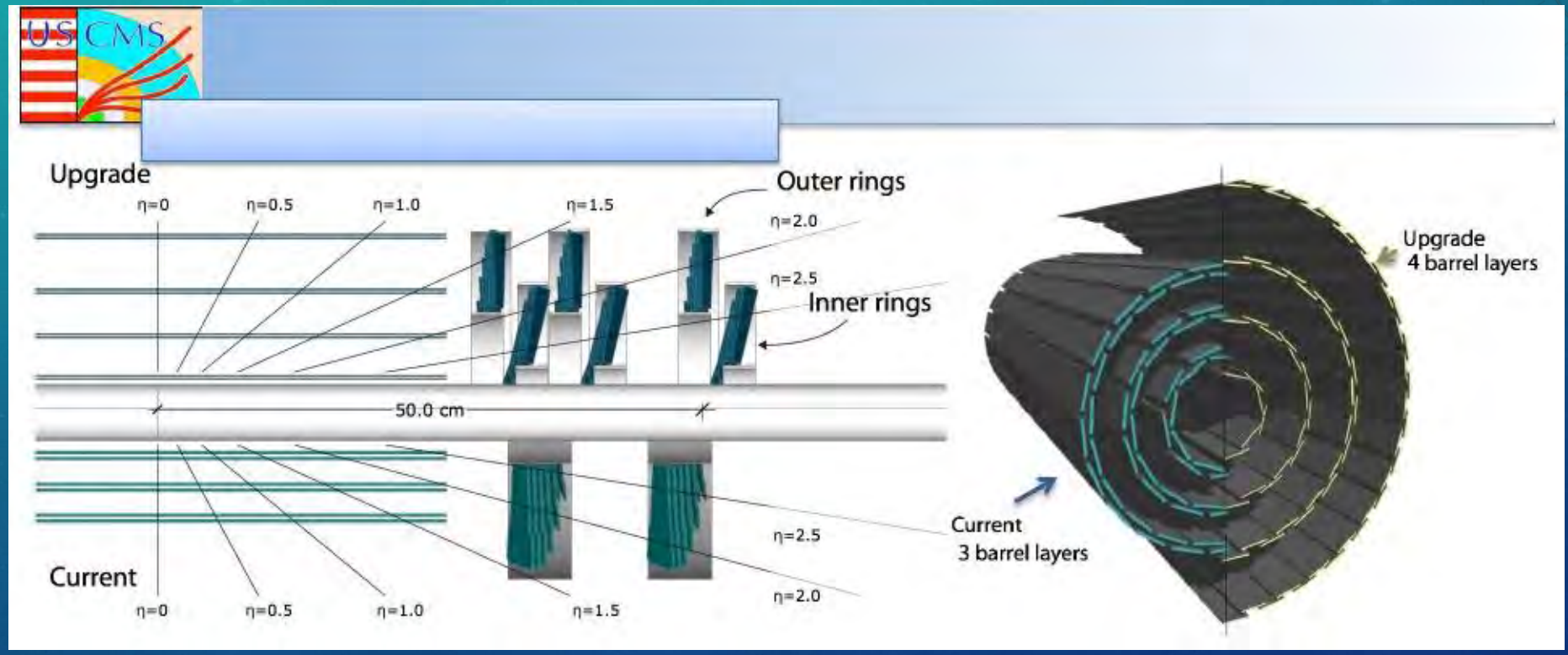
## Current Detector

- 4 blade assemblies
- Cold Water
- Be/Al
- 3 layers of silicon modules in barrel
- 672 silicon modules mounted flat

## New Detector - Improved track reconstruction and resolution

- 6 blade assemblies - Improved track resolution and efficiency
- 2 phase $CO_2$ Cooling
- Graphite and carbon fiber
- 4 layers of silicon modules in barrel
- 672 silicon modules at an angle
- ***Approximately*** $639,000 for one HC, parts and labor only – no design , no pre-production, no prototypes

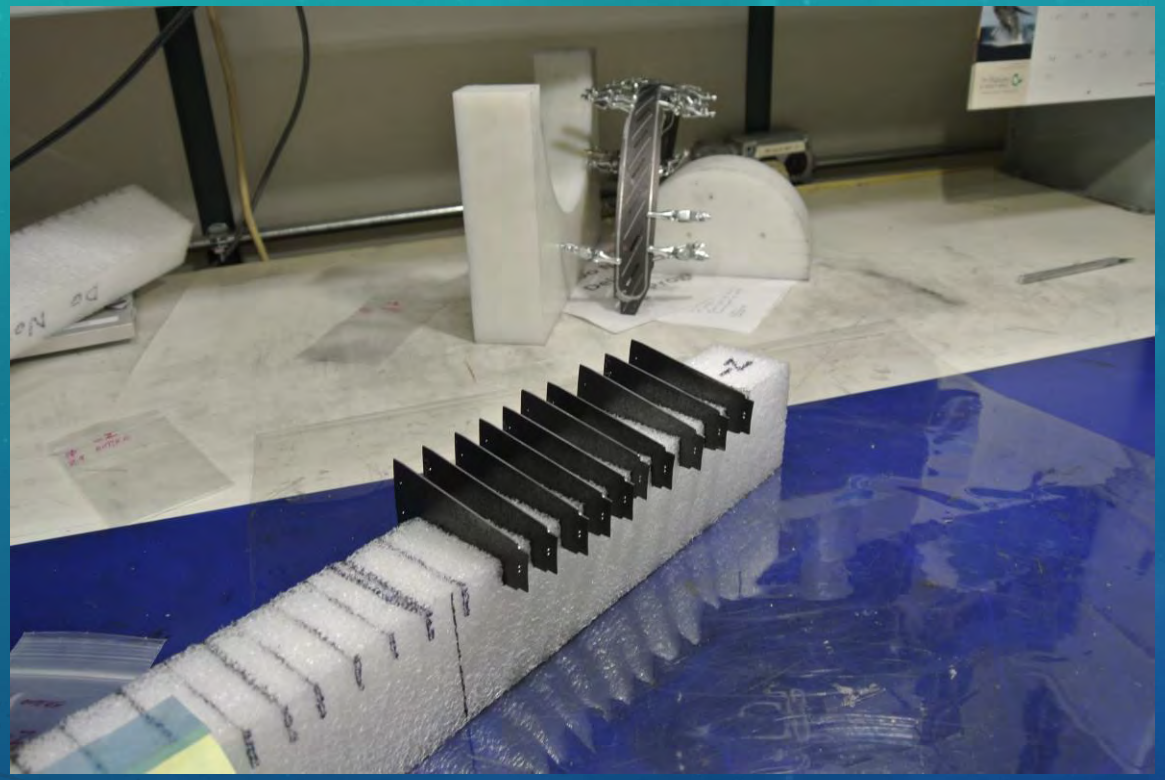
# OLD VS. NEW PIXEL DETECTOR

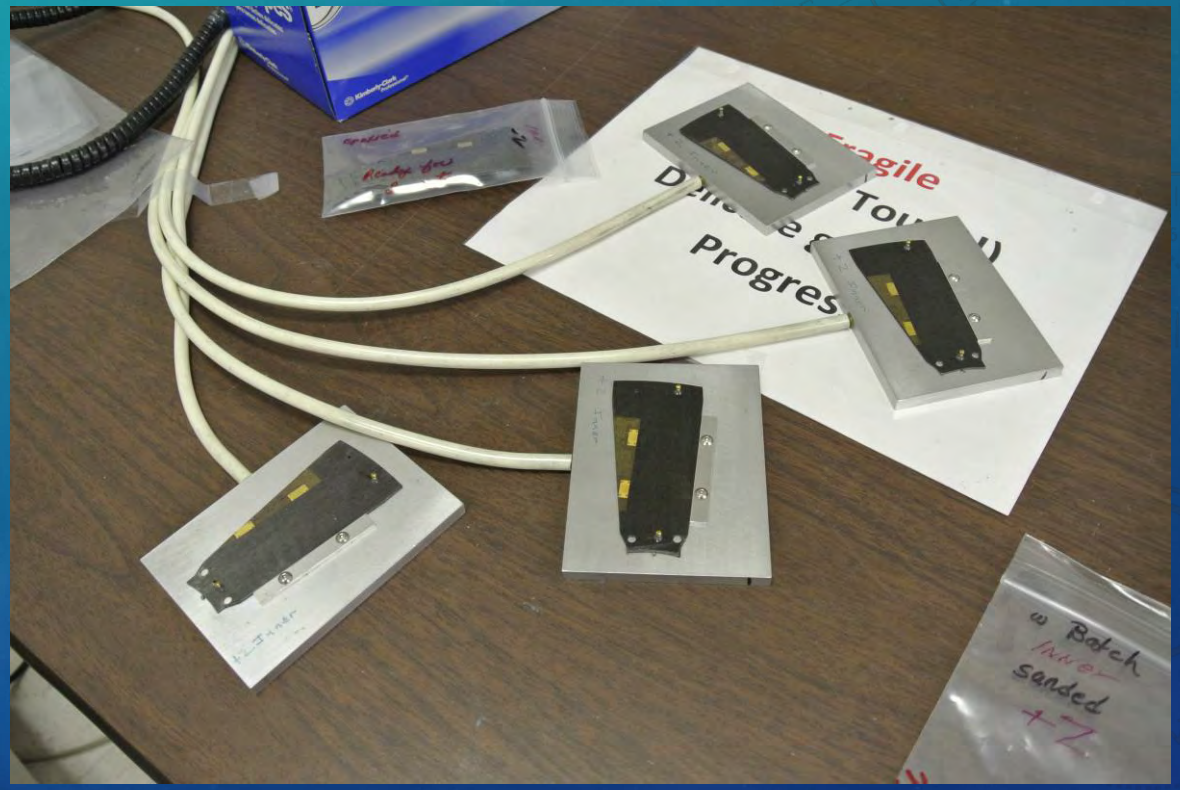


# DETAILS – BLADE AND MODULE ASSEMBLIES

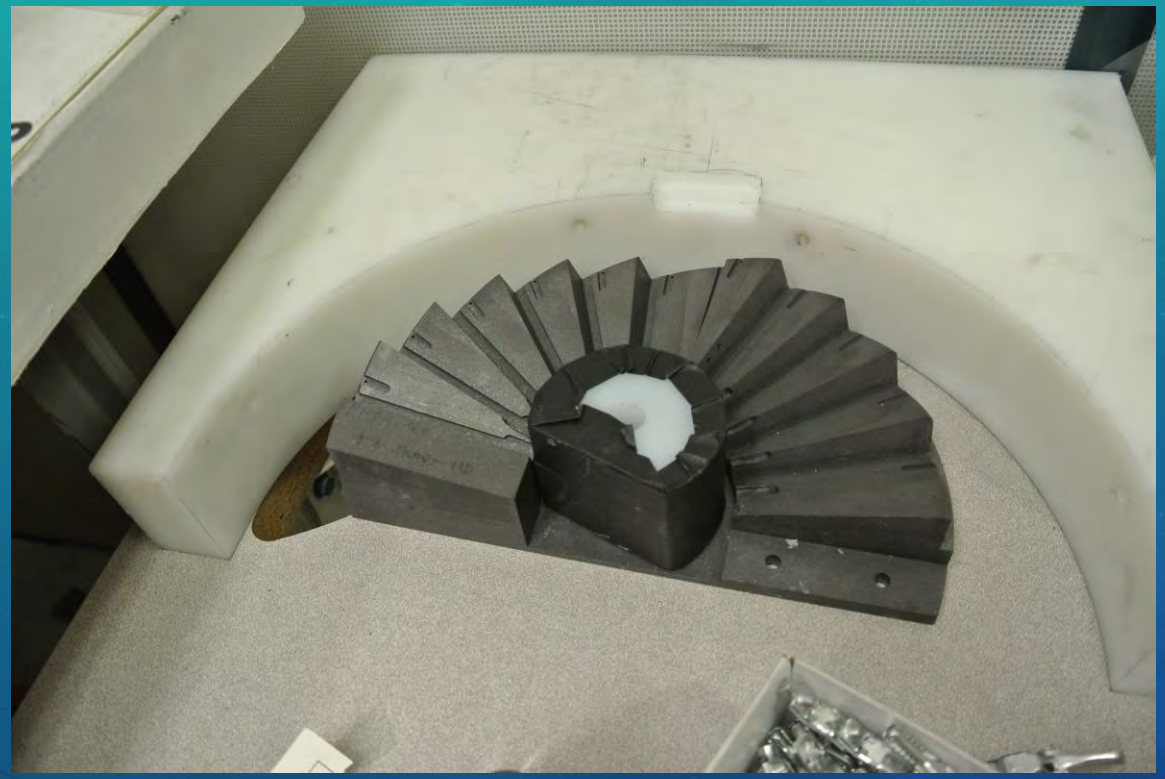
- Move more of the material/electronics further from the IP
- One module type (2x8), that can be removed from blade if needed
- Independently mounted inner and outer half disk, inner half disk can be replaced if needed
- Takes ***approximately*** 360 man hours to build out one blade assembly

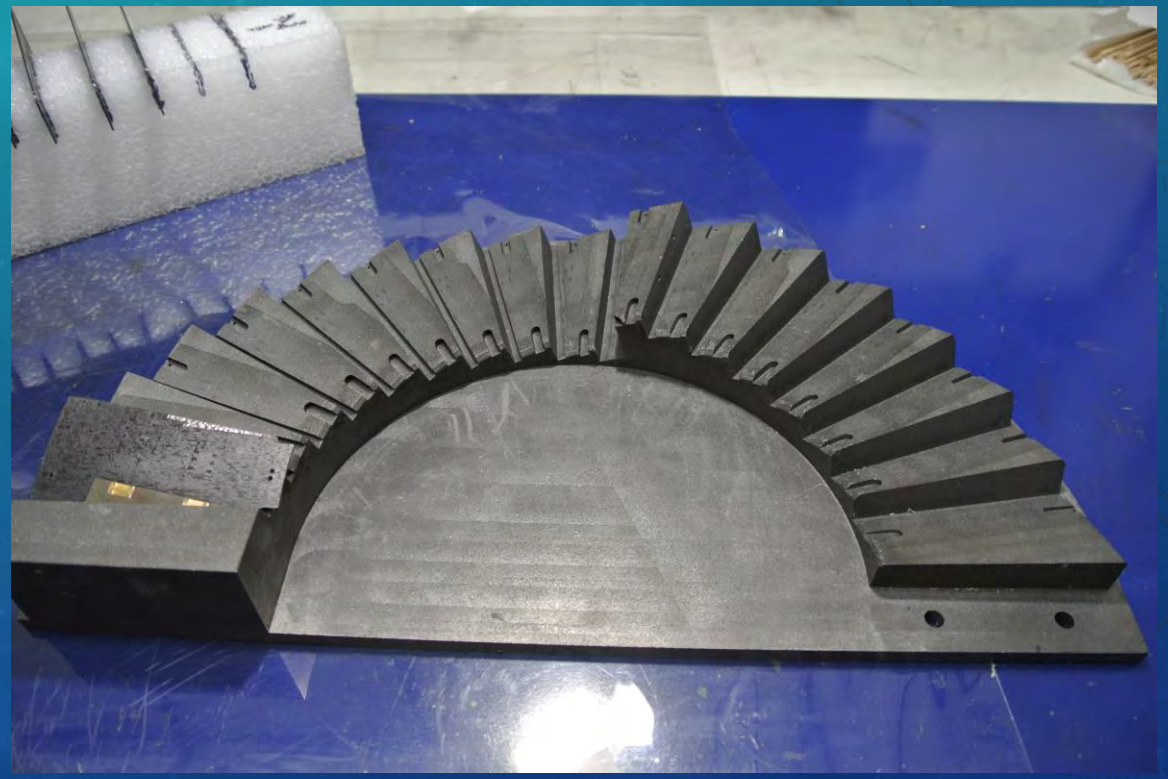
# BLADES BEFORE RING PLACEMENT





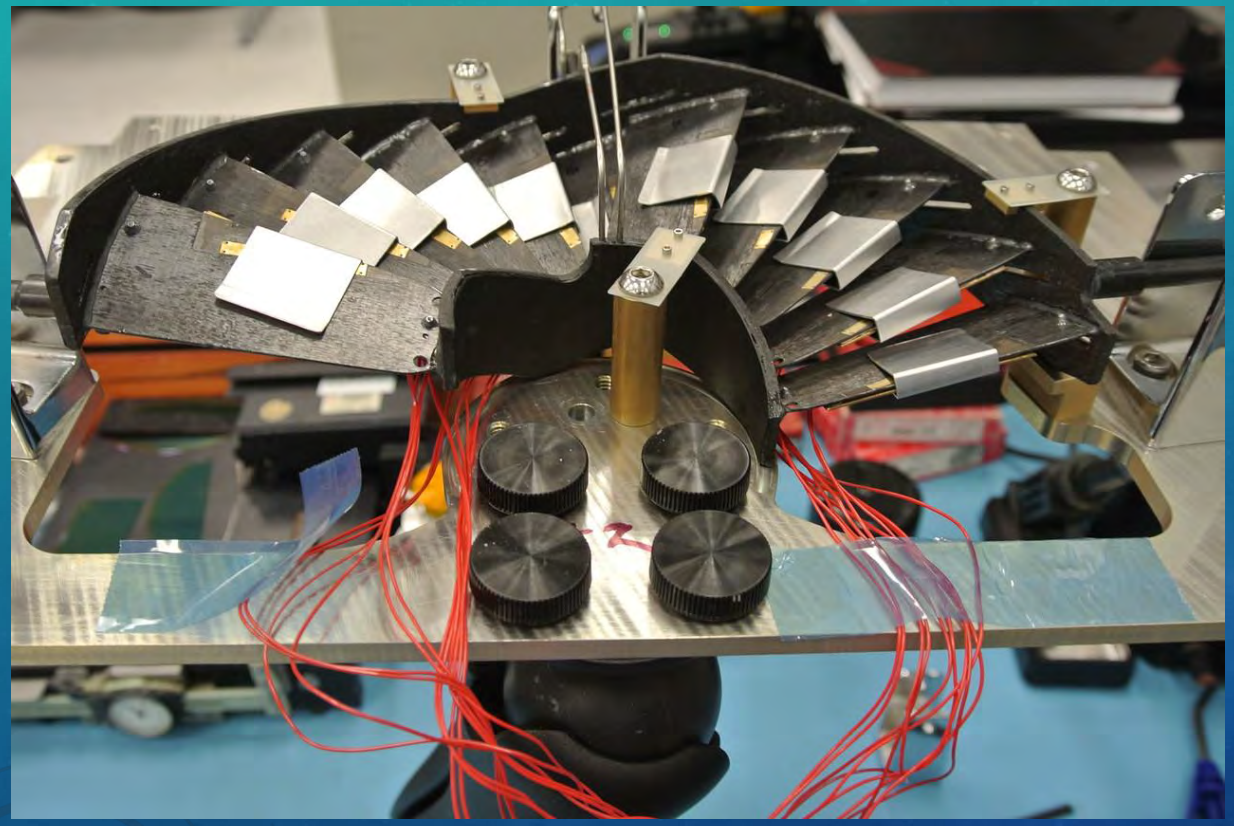
# TEMPLATES FOR BLADE PLACEMENT IN RING





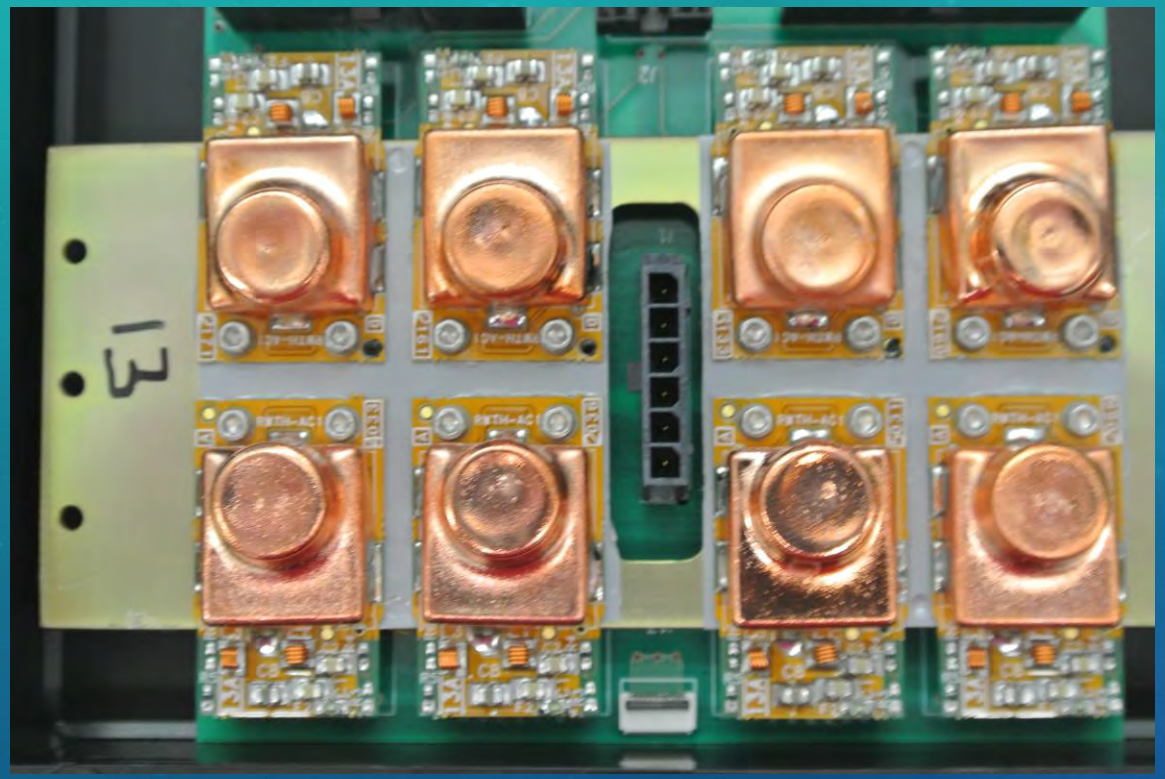
# COOLING TUBING PLACED IN RINGS

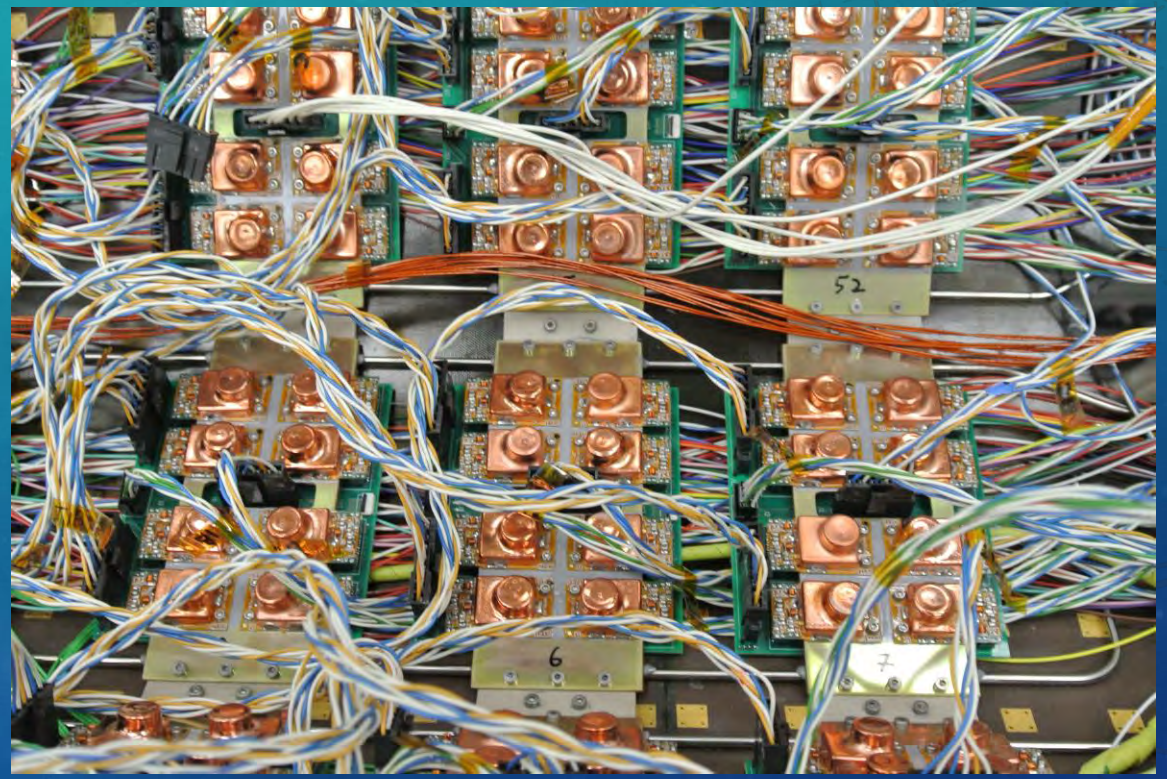
# INSIDE AND OUTSIDE BLADE ASSEMBLIES



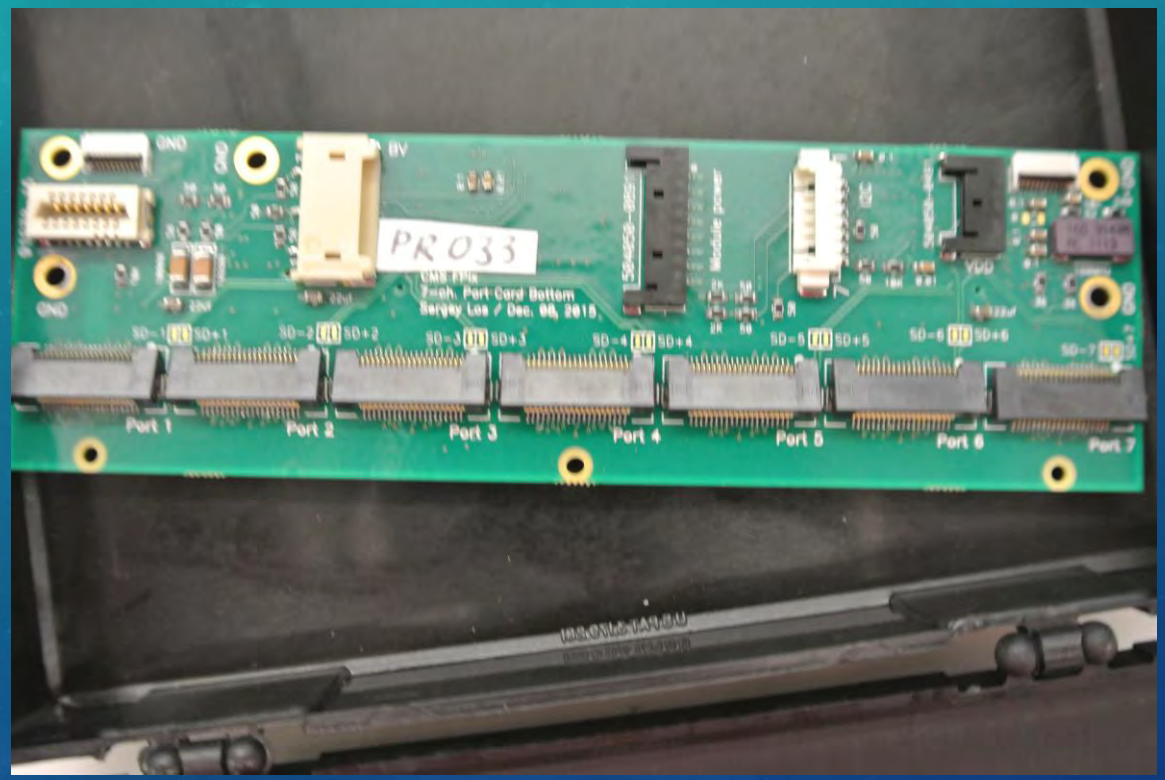
# Electronics

DC-DC converters step down voltage for the electronics. 12 each

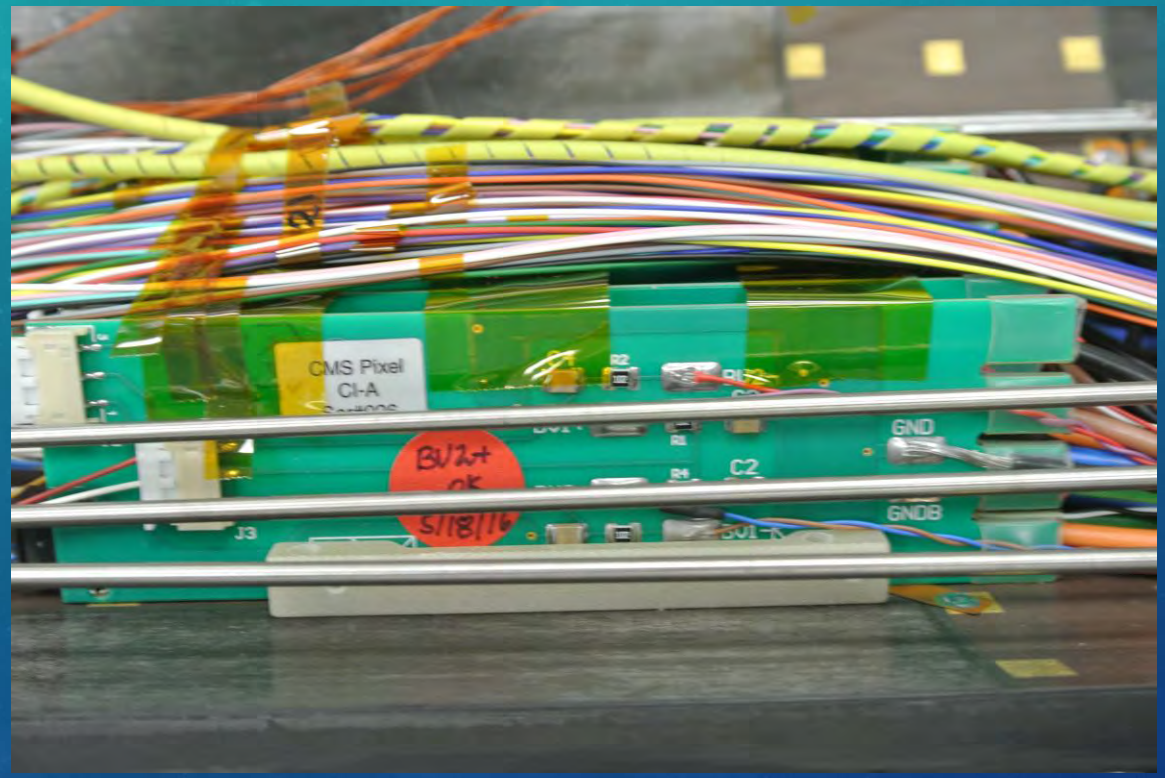




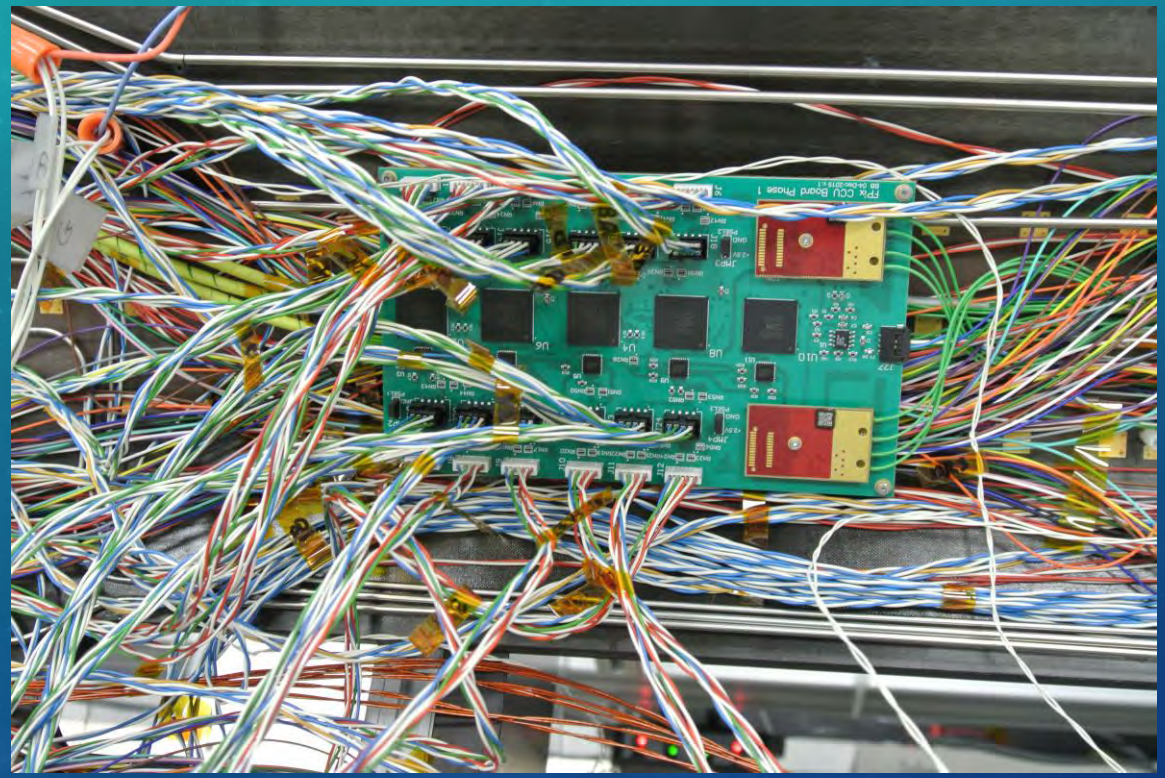
Port cards have an input high voltage (~100-600V) that allows the sensors to be sensitive to charged particles, they convert electrical signals into optical signals.  Port cards talk to and control the modules. 12 each



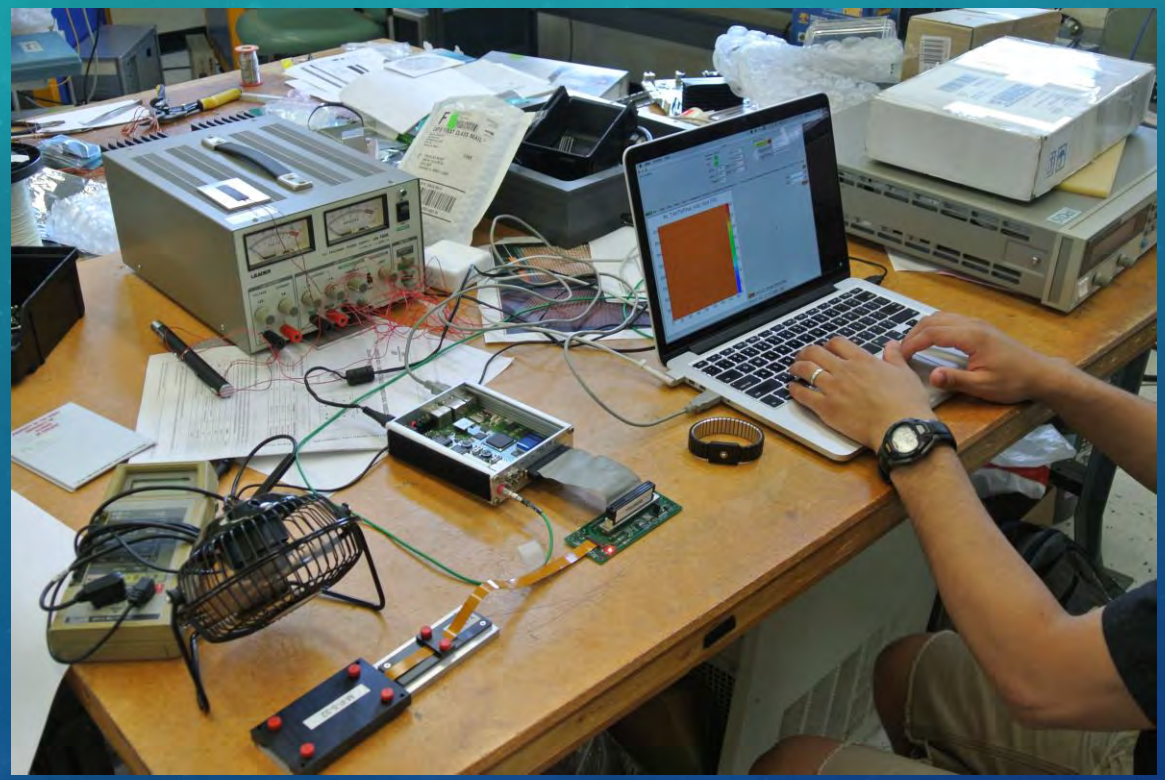
Filter boards are for power. 15 each



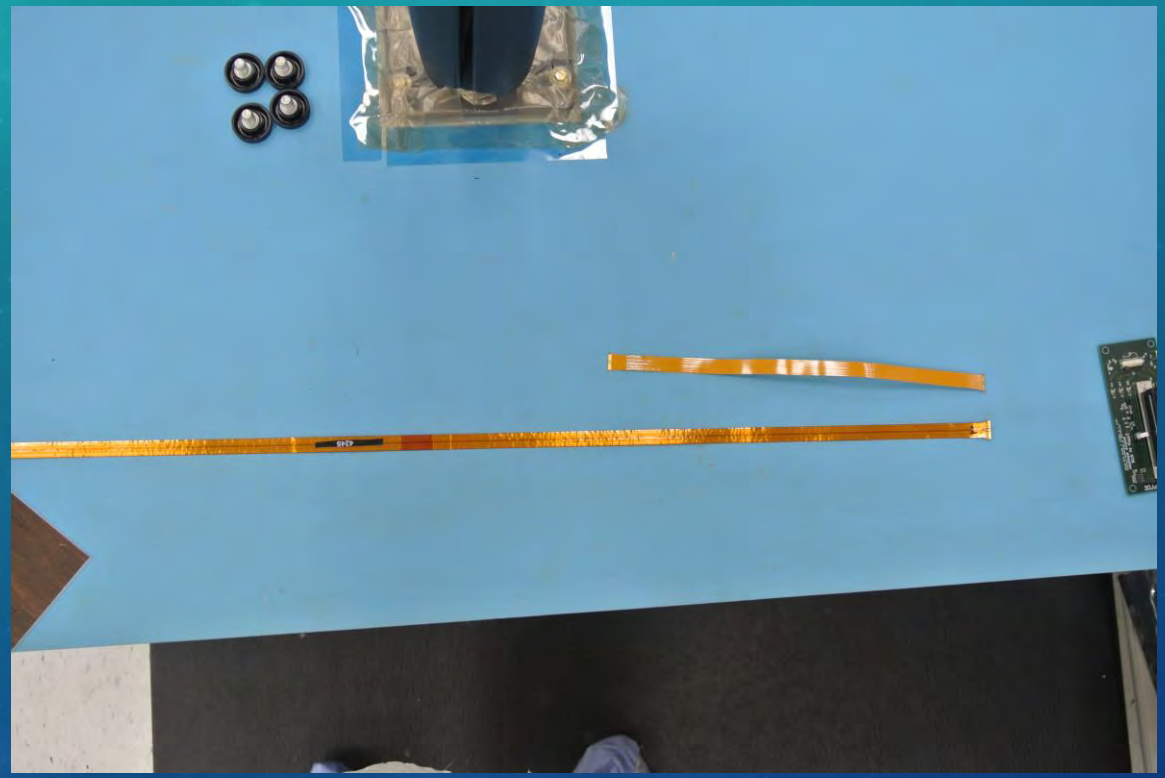
CCU - Is for talking to all the port cards and controlling what they do.  It seems to run the show.  It can talk to one port card at a time or multiple.



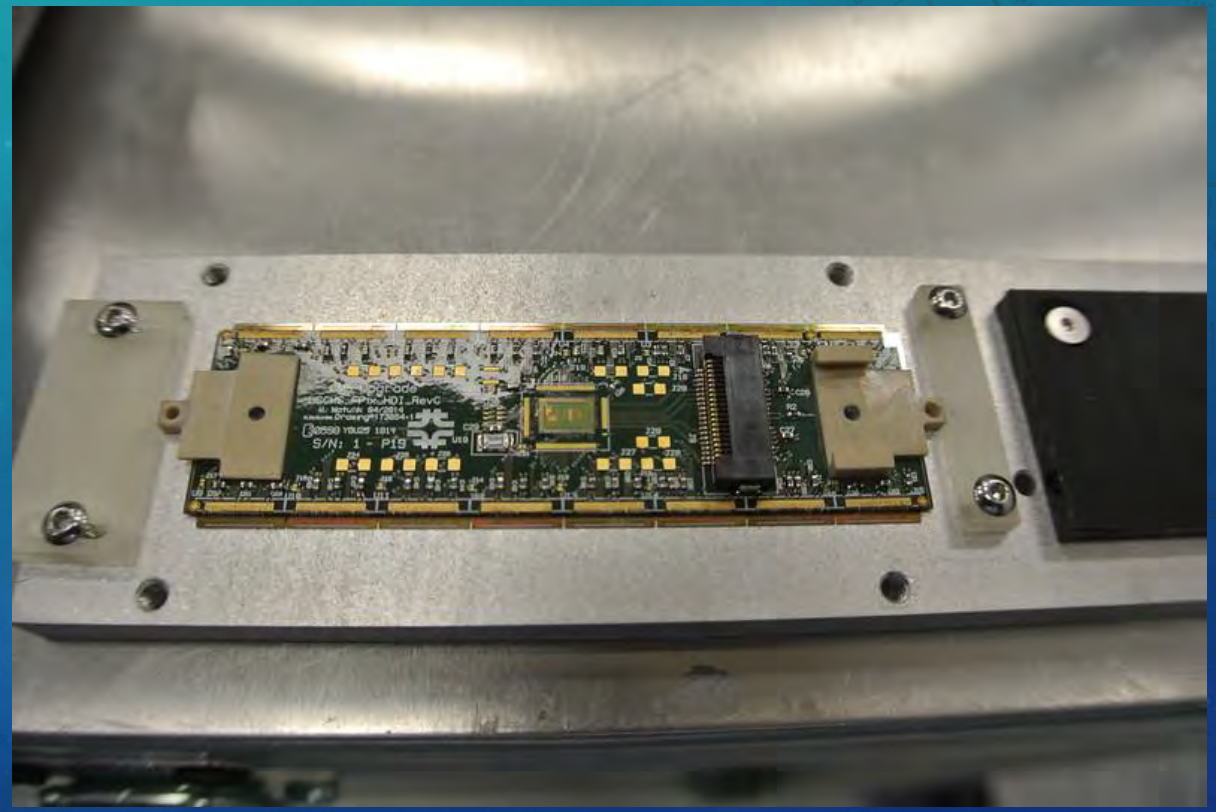
# TESTING STAND



# CABLES



# ELECTRONICS



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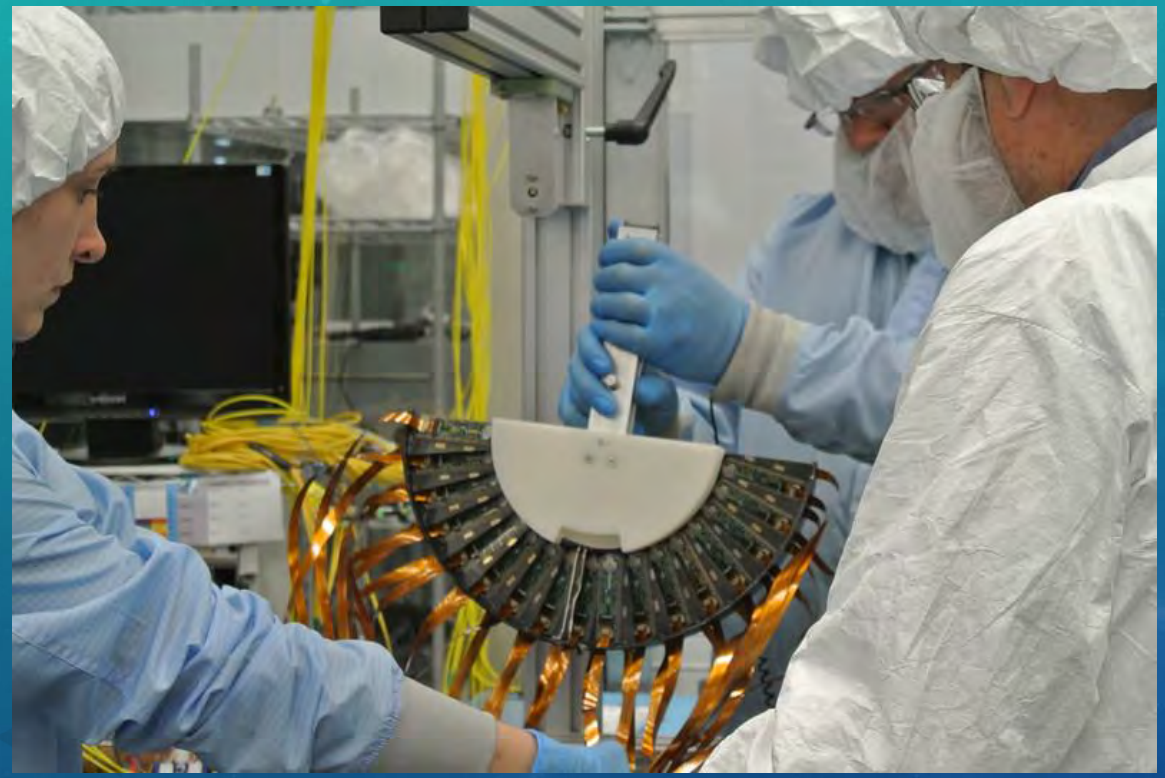
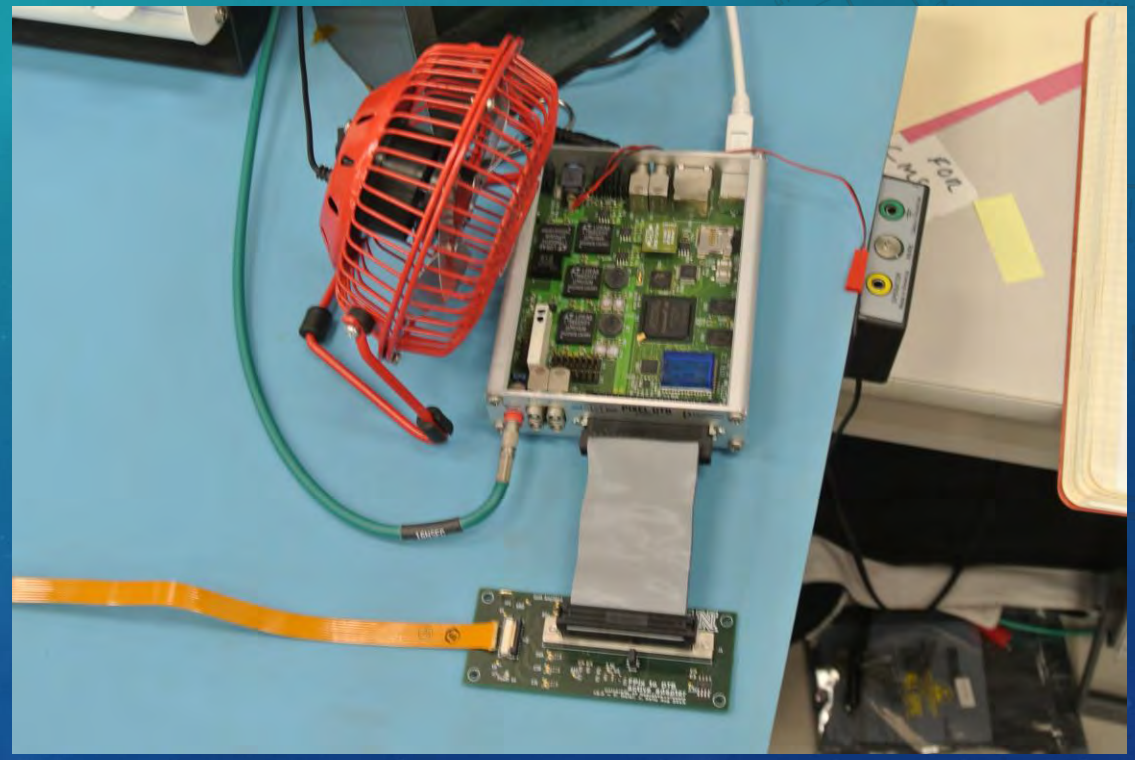
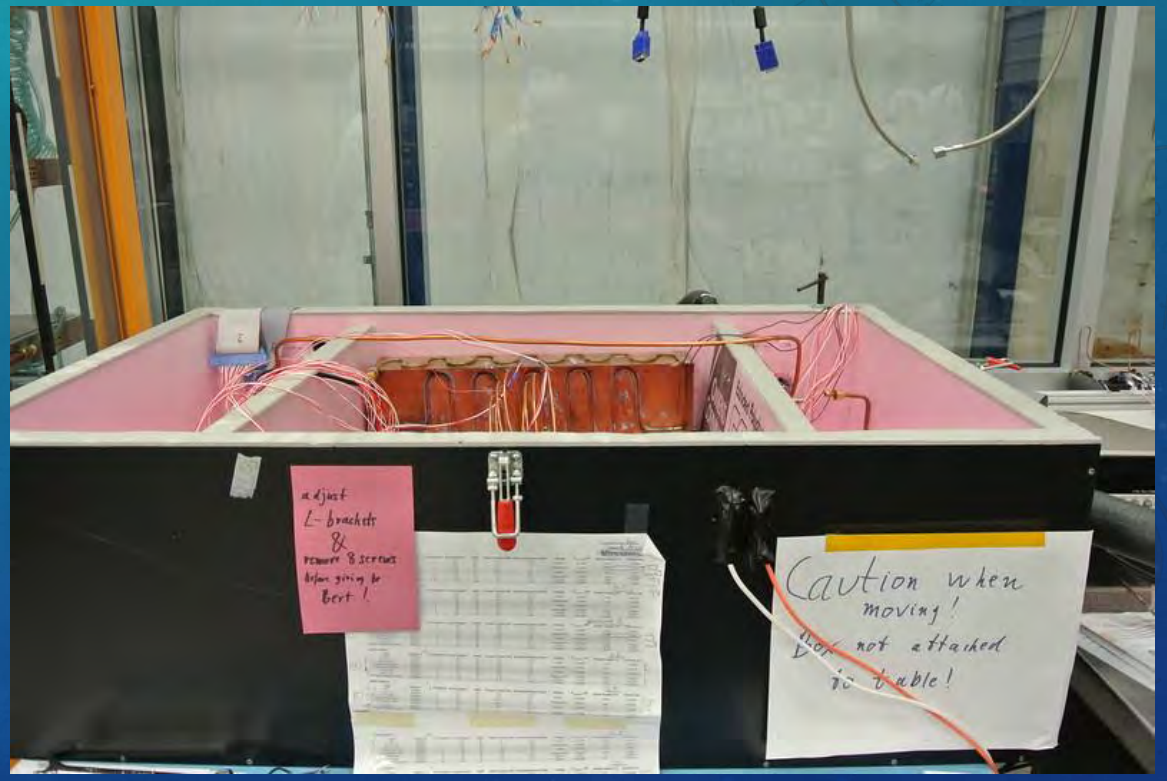




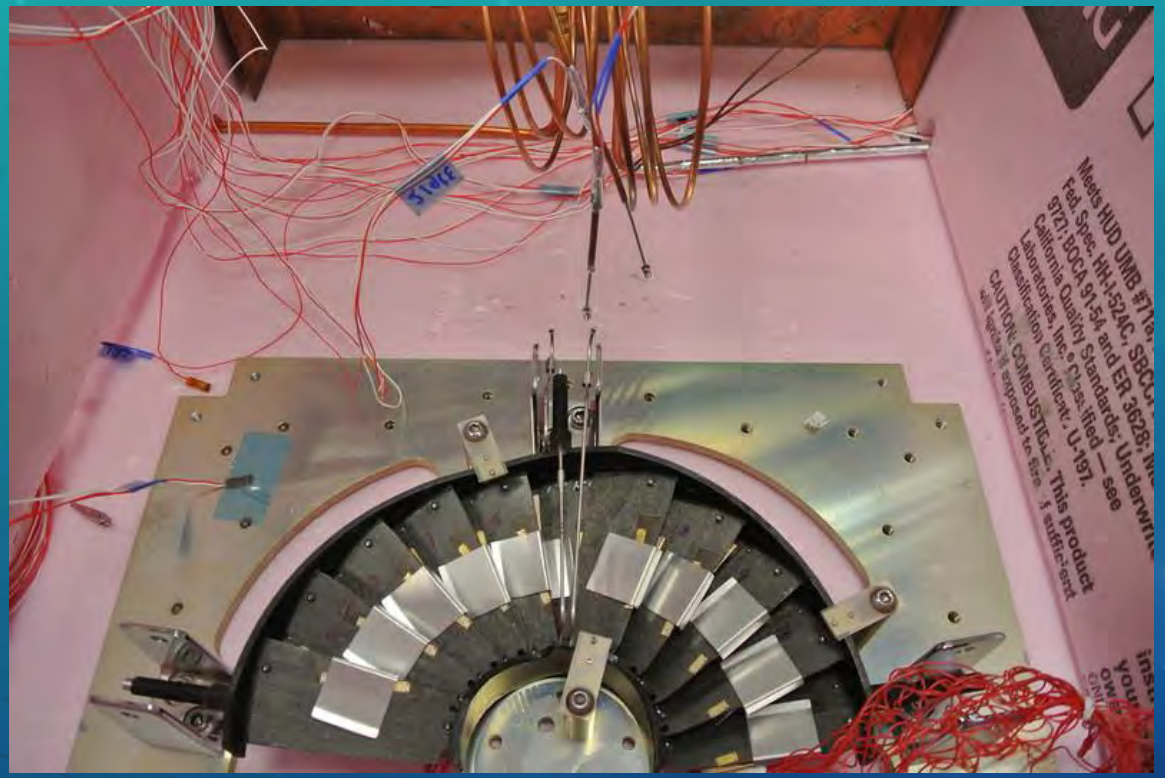
# MECHANICAL

- Thermal testing of carbon fiber blades
- Thermal testing data evaluation and consolidation
- Thermal testing of completed blade assemblies
- Installation of Resistance Temperature Detectors (RTDs)

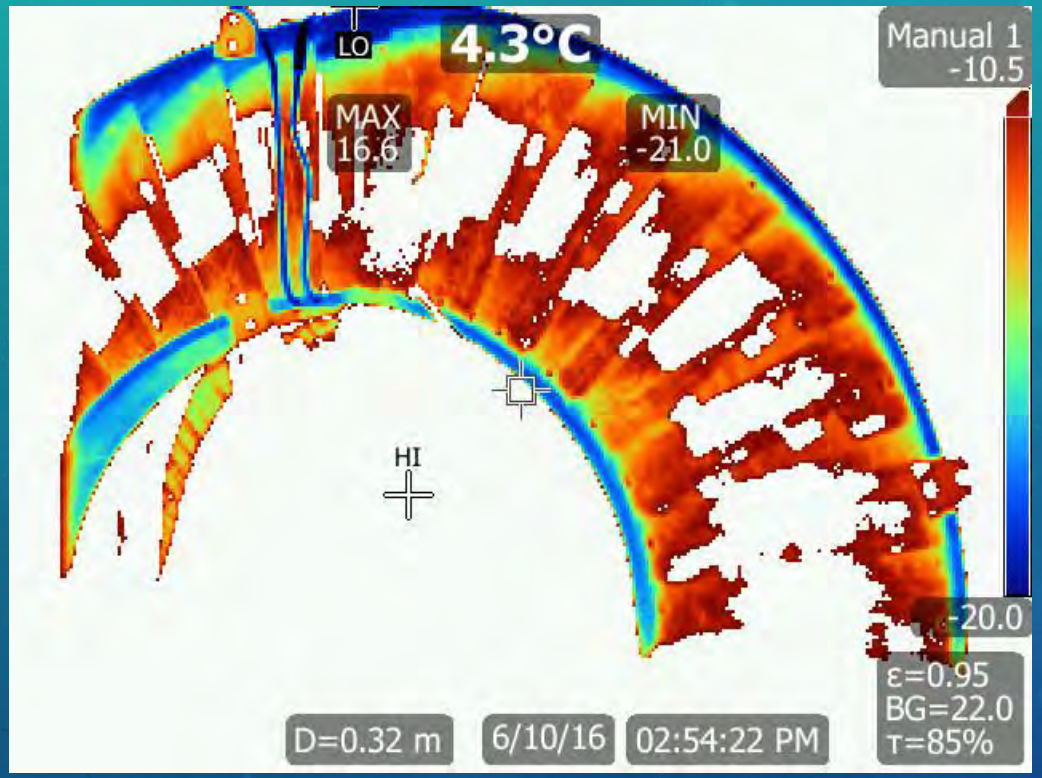
# THERMAL TESTING OF CARBON FIBER BLADE ASSEMBLIES

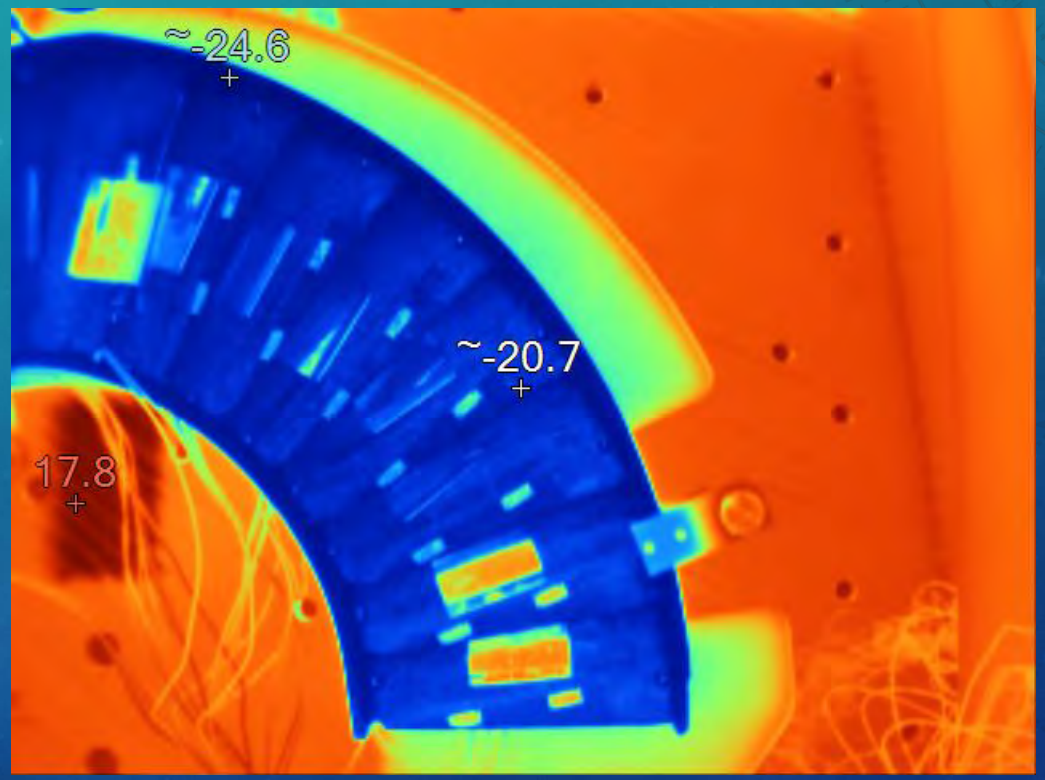


# THERMAL TESTING CONTINUED



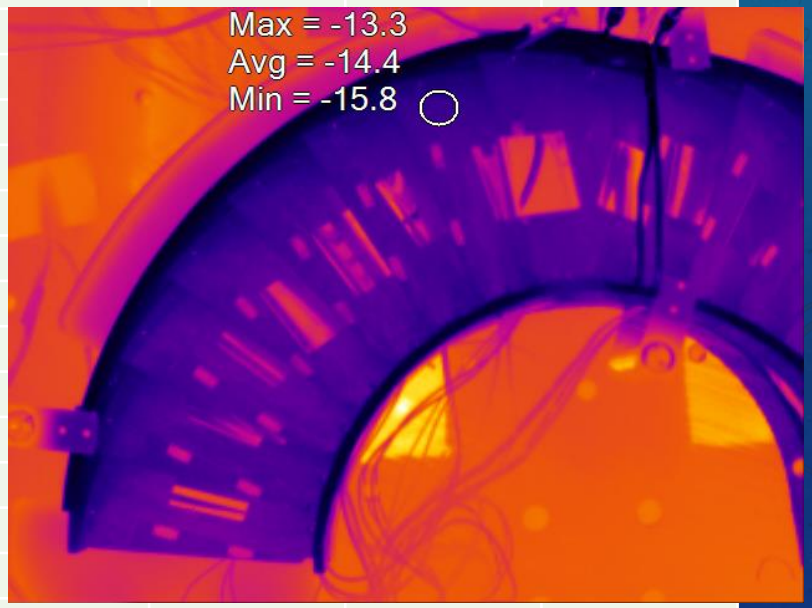
# TEST RESULTS



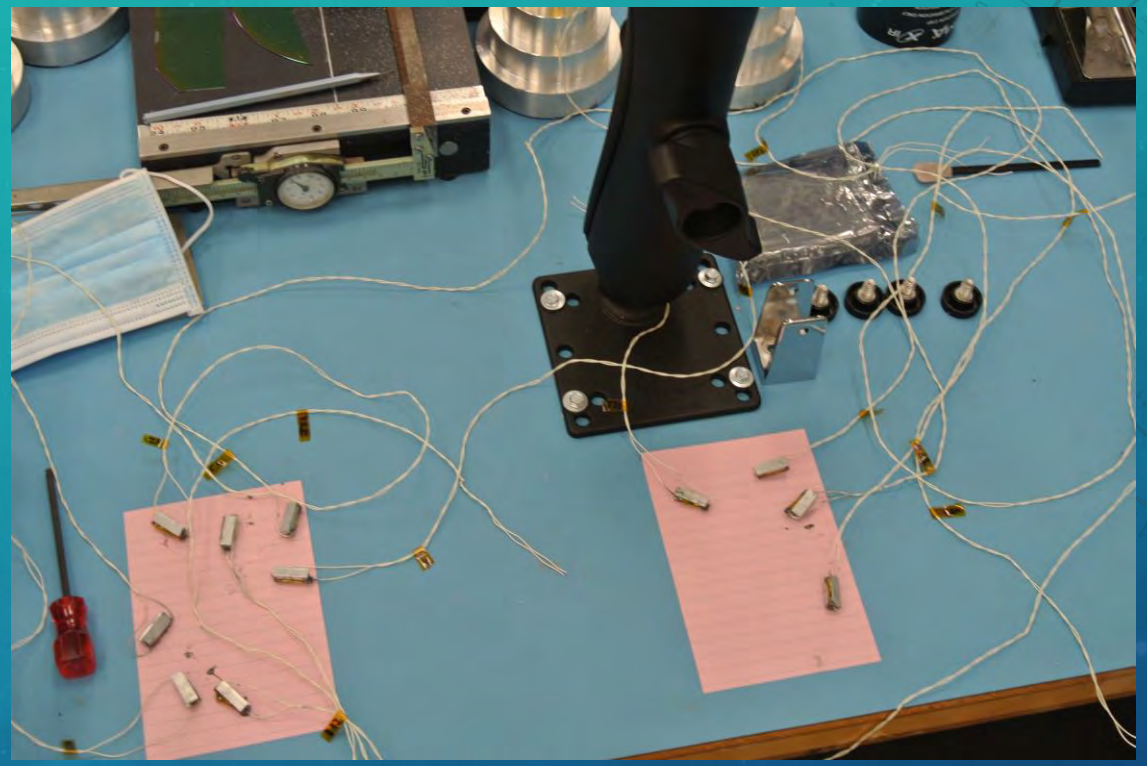



# DATA CONSOLIDATION

| | Marker Info for MO5 20160518 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Label | Min | Avg | Max | Stdev | Unit | IR imagenumber | Avg System Temperature | |
| Blade 17 | -12.4 | -11.6 | -10.5 | 0.37 | °C | 159 | -19.34 | +/-1.34 |
| Blade 16 | -13.7 | -12.7 | -11.7 | 0.46 | °C | 159 | | |
| Blade 15 | -12.7 | -11.7 | -11 | 0.36 | °C | 159 | | |
| Blade 14 | -12.7 | -11.7 | -11 | 0.38 | °C | 159 | | |
| Blade 13 | -13.8 | -13 | -12 | 0.37 | °C | 159 | | |
| Blade 12 | -13.8 | -13.1 | -12.3 | 0.29 | °C | 159 | | |
| Blade 11 | -13.7 | -12.9 | -12.2 | 0.36 | °C | 159 | | |
| Blade 10 | -14.1 | -13.1 | -12.3 | 0.4 | °C | 159 | | |
| Blade 9 | -19.1 | -15.1 | -13.9 | 0.72 | °C | 154 | | |
| Blade 8 | -15.4 | -14.5 | -13.7 | 0.4 | °C | 154 | | |
| Blade 7 | -15.8 | -14.4 | -13.3 | 0.5 | °C | 154 | | |
| Blade 6 | -15.3 | -14.2 | -13.1 | 0.49 | °C | 154 | | |
| Blade 5 | -14.8 | -13.9 | -12.7 | 0.41 | °C | 154 | | |
| Blade 4 | -13.8 | -13.1 | -12.2 | 0.37 | °C | 154 | | |
| Blade 3 | -14.2 | -13.1 | -12.1 | 0.41 | °C | 154 | | |
| Blade 2 | -14.6 | -13.7 | -12.7 | 0.41 | °C | 154 | | |
| Blade 1 | -14.7 | -12.8 | -11.4 | 0.6 | °C | 154 | | |



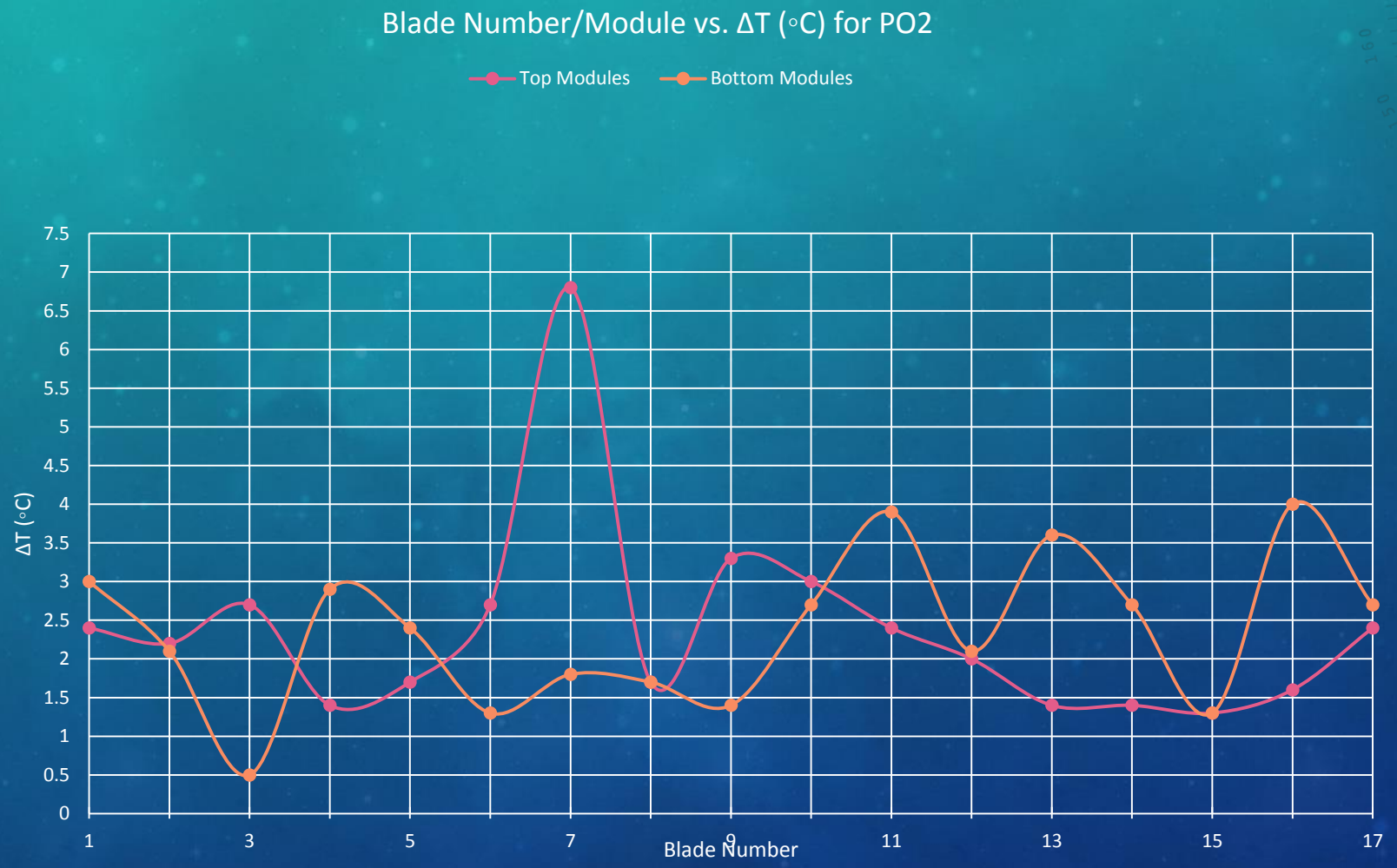
# RTDS



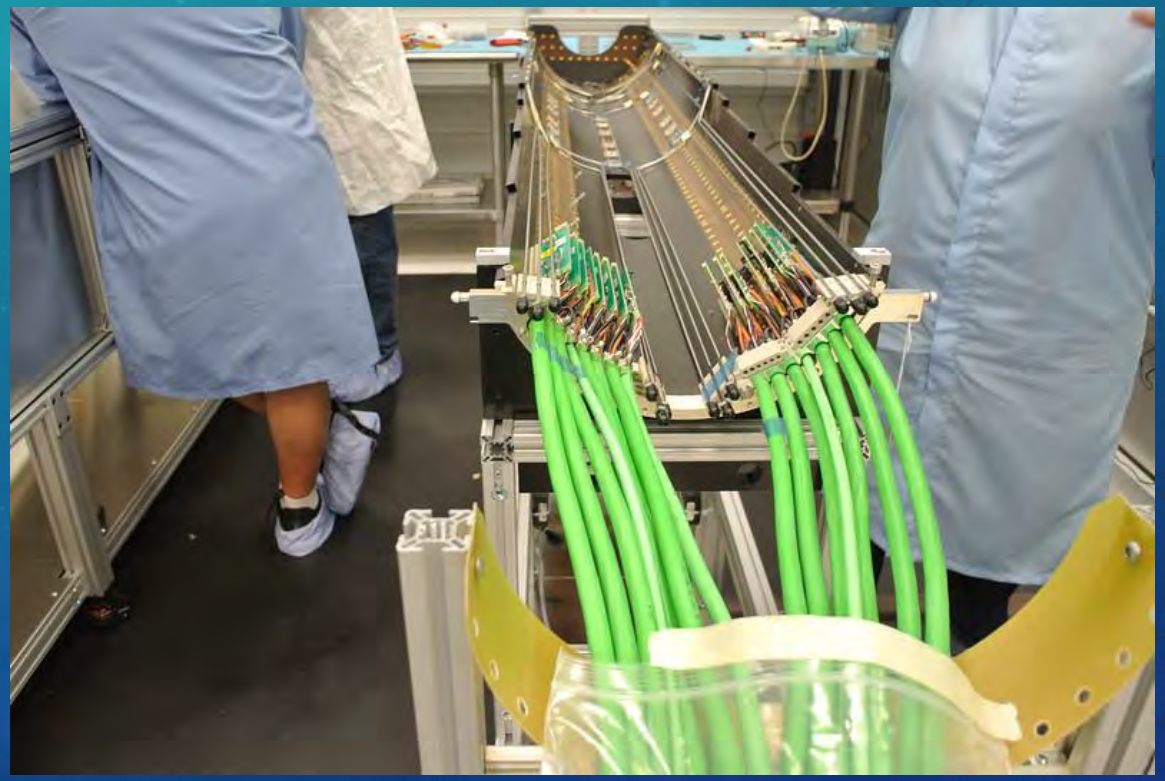
- Wrap RTD in kapton tape
  to prevent shorts
- Slide RTD into slot, syringe in TF52, then epoxy RTD in place
- Attach aluminum block to CO2 supply/return lines with TF52, tie on with aluminum wire, and then epoxy in place

# THERMAL TESTING OF COMPLETED BLADE ASSEMBLIES

# THERMAL TESTING CONTINUED



# BUILD OUT OF HALF CYLINDER 1



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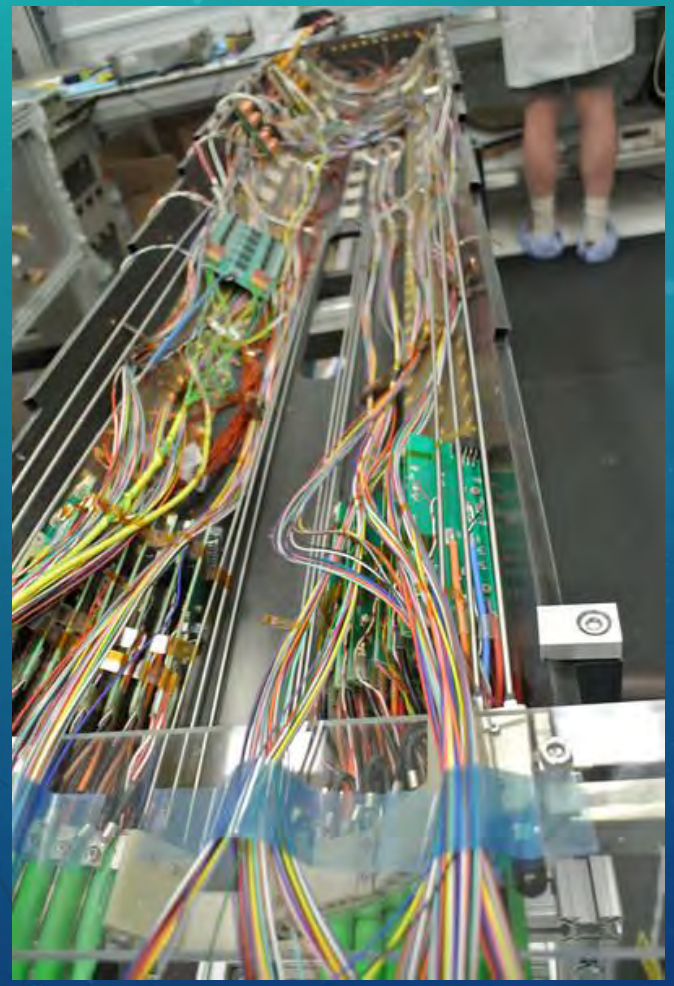

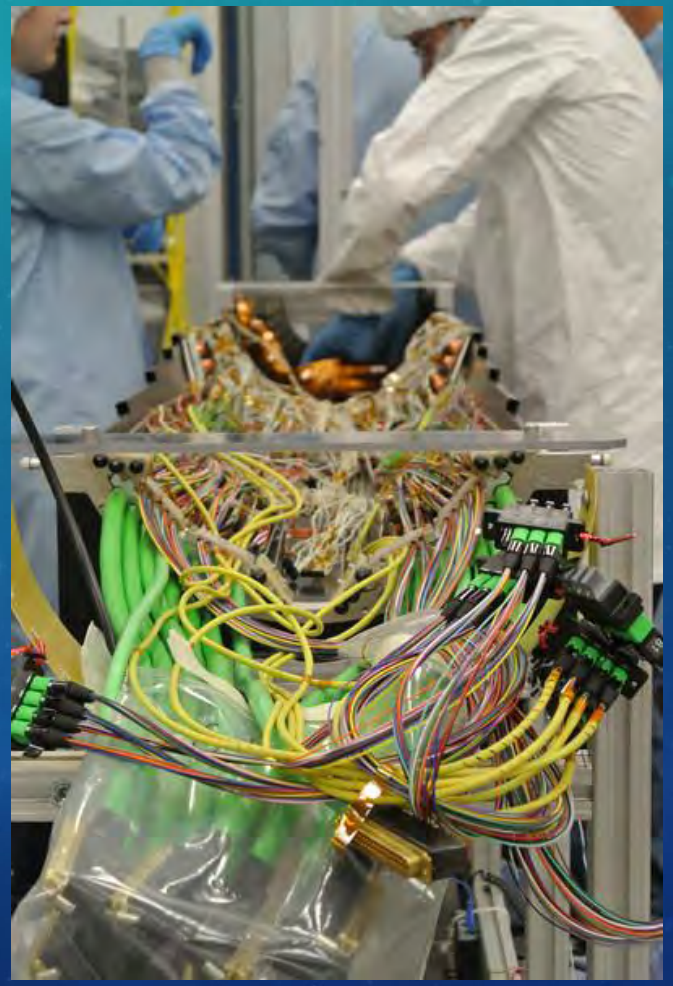

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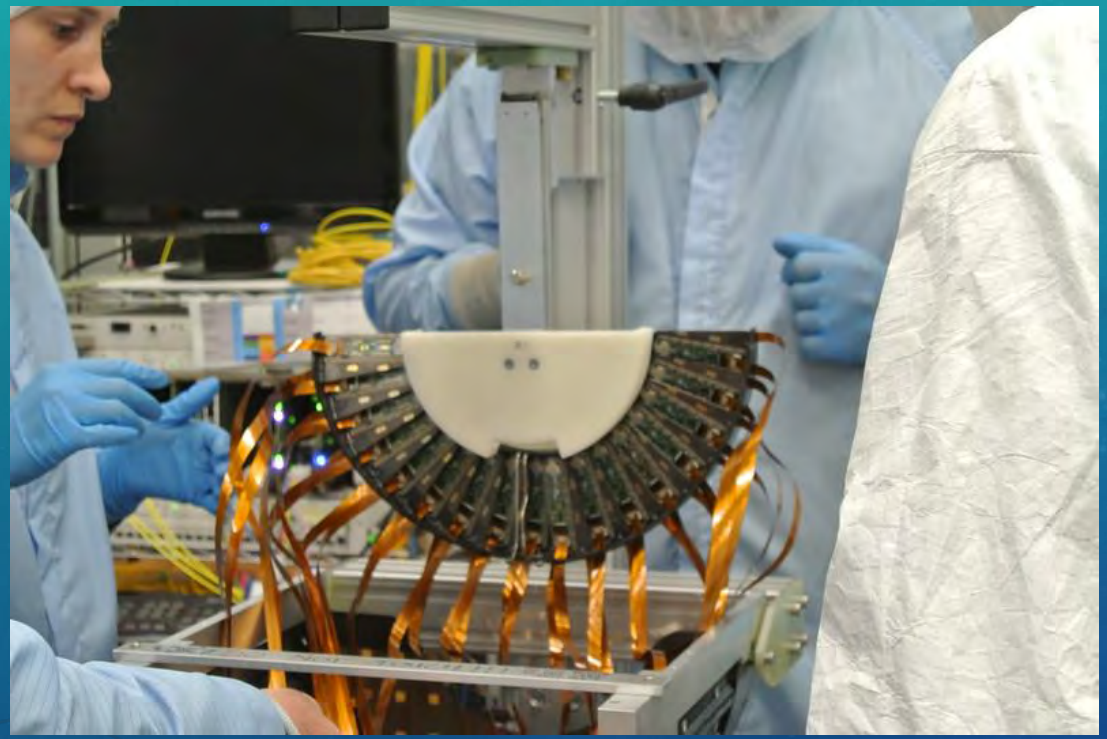

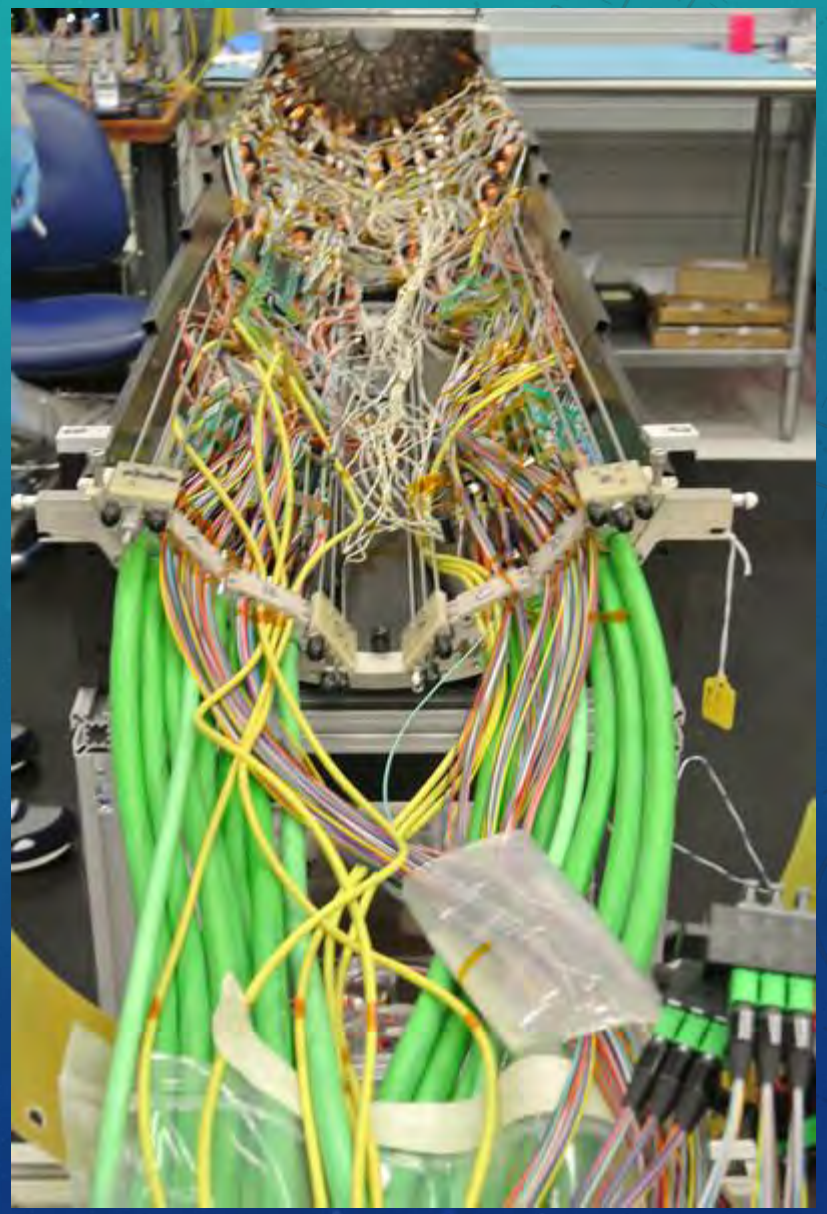

# TEACHER WORKSHOP AT WAUBONSEE COLLEGE

- Learned about gravitational waves, neutrinos, and CMS detector
- Learned about quarknet and did some activities from quarknet (iSpy)
- Did some histogram activities – dice rolling and the pennies
- Homework answer portion was beneficial
- Speakers and presentations were excellent

# THANK YOU

- First, thank you to our mentors, we wouldn’t be here without you
- Second, thank you to Fermilab for offering and sponsoring this program, it has been an incredible experience
- Teacher resource center is wonderful, great place to find help
- Our mentors, Petra and Stefan, were fantastic, patient, and fun
- Everyone we worked with was helpful, knowledgeable, and professional

# TAKEAWAYS - OZMENT

- Now have the knowledge and confidence to talk about fundamental particles
- Will introduce basic particle physics concepts to Honor's Chemistry Students during the atomic structure unit
- Will present her experiences here at Fermilab with her students, the science department at Walton, the Walton administration, and the Cobb County School science teachers on our professional development day

# TAKEAWAYS - DEVITT

- Much more confident in existing knowledge
- Will continue to show the standard model to Chemistry classes
- Will continue doing cloud chambers with Physics I, and adding a few days of particle physics and histogram activities
- Spends 8 weeks on particle physics in Physics II, will continue and add this years experiences to the unit.
- Will continue using Quark Workbench